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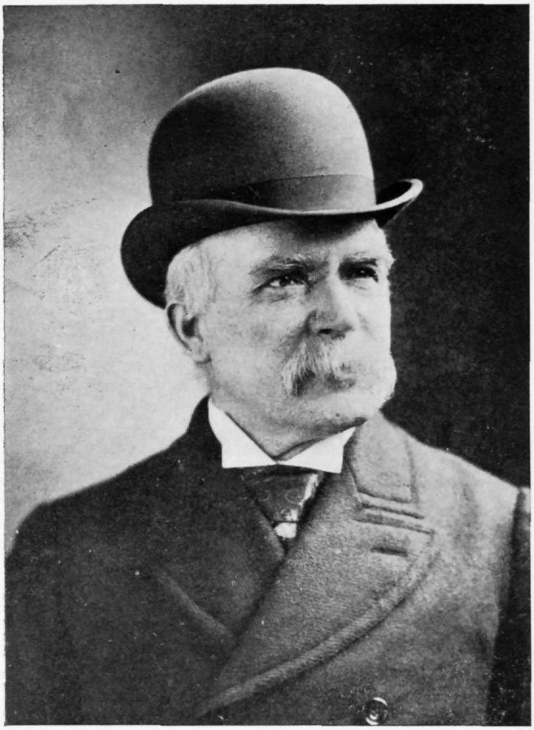

WM. CLIFFORD.

FURNACE VERSUS FAN VENTILATION.

WILLIAM CLIFFORD, M. E., PITTSBURG, PA.

No question of a technical nature so nearly concerns the mine owner and mine manager as that of ventilation; and as we look back at the varied appliances used by our fathers for that purpose, we are amazed at the progress made in *mechanical* ventilation during the past forty years.

The water fall, and the fire lamp, gave place to the modern furnace; and whilst the great superiority of the furnace as a means of ventilating mines, over all other methods then in vogue, left no room for doubt, its lack of economy in shallow pits, and the standing menace of an open fire in gaseous ones (notwithstanding the safe-guards, of fresh air furnace feed, and "dumb drifts"), stirred up men of science to devise means which should at least remove this paramount and continuous danger.

With the advent of the earliest and crudest of mechanical ventilators with which we are acquainted, came a great saving in fuel over the furnace in *shallow mines*. This gave an additional incentive to the use of fans.

Just before Guibal fans were first generally applied to the ventilation of coal mines the furnace had reached a very high degree of efficiency; and as will be observed in table given later, furnace coal consumption had been brought down in the deep pits of the North of England to the level, and in some cases below the level of that of existing mechanical ventilators. This was especially the case where the waste heat from underground boiler fires was available to supplement the furnaces in the production of motive column.

Furnaces were constructed upon the most scientific principles, with double, and sometimes treble arches and side walls, with air spaces between them, in order to isolate the strata from the hot mass of brickwork forming the furnace proper, and also to prevent a large radiating surface to the air passing over the top of the arch in case of a return air fed furnace. Long before Siemens had brought out his regenerative furnace, you all so well know in connection with steel making, pitmen had introduced checkerwork into their furnaces, to store away quickly generated heat and increase the radiating surface presented to the moving air.

Furnaces at this period were divided into two classes: fresh air fed, and return air fed. The former were invariably used in fiery mines. With a fresh aid fed furnace, the shaft was provided with what was called a dumb drift, which was an inclined way, driven from the junction of the main return air ways, to a point in the shaft sufficiently distant from the bottom, to be out of the reach of the flame of the furnace. Through this drift the return air from the workings passed into the shaft.

Even with such an arrangement unceasing watchfulness and care were required to prevent accident. The charring, and sometimes blazing of wood guides, when the furnace shaft was used for hoisting was met by the substitution of railroad iron for wood; but the firing of the soot in the furnace drift and lower part of shaft, was a danger more difficult to guard against. In many collieries set times were appointed for examining the furnace drift, and clearing out the accumulations of soot. On such occasions the manager or chief overman would take the opportunity to examine the sides of the shaft by standing on the tops of the cages or sitting astride of a "horse" (an iron seat suspended by chains), and in specially dangerous pits an overman similarly suspended would watch the mouth of the dumb drift with a safety lamp during the time the men were at work cleaning out the drift below. Owing to the heat stored up in the shaft sides usually keeping a good circulation of air going, the position of the overman was more disagreeable than dangerous.

Speaking of dumb drifts, it may be remarked that many able and experienced viewers held strongly, that they were a superfluity — that when the return air of a mine was not fit to pass over a furnace fire, it was not safe to work.

Deep pits lined with brick-work, — sometimes firebrick blocks, of large size — and furnaces and airways as described, enabled the management to keep fiercely burning and incandescent fires, over grate areas of 70 to 100 superfeet and more in a single furnace, and in some cases, as at Hetton, to have three of these furnaces at the bottom of one shaft; and by such means circulate large volumes of air through the roadways of their mines. Hetton with 200,000 cu. ft. per minute. Ryhope with a little more. The Oaks at the time of the explosion 156,000;

while about 23 years ago the writer in company with the late Edward Beacher measured 238,000 cu. ft. in the returns of Lundhill. The climax of furnace ventilation, however, is to be found at Murtin Colliery in the county of Durham, England, where 490,000 cu. ft. per minute are circulated through the workings by means of furnaces placed at the bottom of an upcast shaft 14 feet in diameter and about 520 yards deep.

The writer had hoped to have shown a drawing of these furnaces and the adjacent airways, but has not been fortunate enough to receive it in time for this meeting.

As we here in America consider the means by which these enormous volumes of air were and are produced, we are apt to think that Providence has been bountiful to us in leaving so thin a cover over the coal we work, and thus delivering us from the temptation to emulate the vigorous example of British mining men, by making the attainment of the same results physically impossible. These enormous furnaces cost very little less than a good fan, and when we contemplate the ever recurring shifts of three and four men each, every eight hours and the huge pile of coal swallowed up every twenty-four hours, we come to the conclusion that efficient furnace ventilation is a luxury which the coal trade of the United States could never stand.

While these remarks apply to deep pits where the motive column in some cases reached 16 lbs. per square foot or roughly 3. in W. G. In shallow mines of say 400 and less feet deep in which inflammable gas was found in quantities, producing ventilation by furnace was so costly as to become an unbearable hardship.

The writer knew of a case of a shaft mine 78 yards deep in which the daily expense of producing ventilation—wages and coal—amounted to $19. A 40 foot Guibal fan reduced the cost to $6 *for one and a half times* the amount of wind previously given by the furnace. That is a typical case of thirty years ago in the Midland district of England. It approaches nearer to, though it is not quite as bad as our own conditions, than do those well ordered deep mines referred to. The fan had a hard time in the beginning; first from the prejudices of the practical man. He had used the "Blow Gauge," or hand blower, in sinkings and in lead mines; but the thought of driving a larger machine by a steam engine raised all the resolute ignorance that was in him. The innovation was intolerable. He was a good man, this practical man of the last generation. His cat-like vigilance and broad sagacity, his fearless courage, joined to unbending firmness, have covered him with a halo of glory in the memories of those who knew him well enough to discover that a true man was often covered by a rough Overmans' jacket. But he and those to whom he was often confidential adviser—the mine owner of that day—were very slow to take to the new fangled machines, from the use of which they predicted nothing but disaster.

There were, however, other men who, equally ignorant but with less excuse, condemned mechanical ventilation as visionary and unpracticable. These were the experts from whom the government sought advice, and so strong were they, that in 1852 a British Parliamentary Committee, *on* such advice, unanimously reported against mechanical ventilation, and expressed the opinion that the only rival powers were the furnace and the steam jet, and *that the steam jet was the most powerful and least expensive method of ventilating mines.*

The first fan to be put into practical use in Great Britain, was that of Mr. Brunton, the civil engineer; it was applied to one of the Navigation pits, South Wales. The fan was horizontal, its axis vertical, and worked in a step supported by a strong iron beam placed across the center of the upcast shaft: only one of these fans was ever built.

From 1852 to 1862 numerous examples of the Naysmith fan were to be seen working in collieries in England, and in the early fifties one was at work in Saw-Mill run in this country (Allegheny county, Pa.). The writer remembers one at Orgreave colliery, Yorkshire, which was kept in such bad repair, that the rattle of it could be heard a mile away. Two of these fans were erected at the colliery of Lord Fitzwilliam, under the superintendence of Mr. Benjamin Biram, with whose name, as the inventor of the Anemometer, we are all familiar. Mr. Biram was manager of the Elsecar collieries. It was upon one of these fans that Mr. J. J. Atkinson, assisted by Mr. John Daglish, made his widely known experiments. Neither of these fans have been removed, one of them (that at Simonwood) is still at work ventilating a coal mine. The publication of Mr. Atkinson's experiments had an important bearing on the development of mechanical ventilation in England. It called the attention of continental inventors to the needs of the English coal mines. One of the first effects was the covering of the open running fan at Tursdale, in the County of Durham, with a Guibal case and chimney, with results that proved the great value of M. Guibal's invention.

Shipley, in Derbyshire, which is not mentioned in the table below, was one of the early Guibal fans.* Staveley and Clay Cross followed and the former company engaged largely in the manufacture of these fans.

FUEL, CONSUMPTION FURNACES, FANS AND GENERAL DATA.

Furnaces.	Depth of Shaft feet.	Volume.	Coal per H. P. per hour lbs.	Water Guage in inches.	Useful effect, per cent.	Remarks.
(1) Thoinley Five Quarter seam....	556	....	85.4	.....	.....	
(2) Thornley Five Hutton seam....	868	....	162.4	.....	.....	
(3) Walker	960	....	80.5	.....	.....	Boilers in pit.
(4) Castle Eden.......	1,038	......	29.1	.....	.....	"
(5) South Hetton....................	1,212	....	27.2	.....	.....	"
(6) Wearmouth...........	1,800	....	29.5	.....	.....	"
Rugeley......	480	103,325	26.6	0.86	.....	
Page Bank.................	300	39,997	39.4	0.94	.....	"
Ryhope	1,380	126,366	26.2	2.15	.....	"
North Seaton	798	99,750	29.2	1.85	.....	"
Trimdon	480	40,000	69.4	0.64	... .	
Pelton..........	318	36,350	69.8	1.60	.....	
Tynemain........................	.....	101,876	59.6	0.925	.....	
Team..................	.....	9,832	267.0	0.27	.....	

*The table in question, with the exception of two or three of the last items in it, is a compilation by the late D. P. Morrison, a very able Scotch mining engineer, who at one time represented N. O. Subal in Great Britain.

RECIPROCATING AND DISPLACEMENT MACHINES AND ARCHIMEDEAN SCREWS.

Year.	Furnaces.	Volume.	Coal per H. P. per hour lbs.	Water Guage in inches.	Useful effect, per cent.	Remarks.
1836	Grand Buisson, Piston	11,783	17.5	5.38	40.	
1839	Letoret-Agrappe, Belgium	8,366	35.	0.80	20.	
1839	Motte Sanwartan, Belgium........	8,950	29.2	0.98	24.	
1840	Combes Grand Horner, Belgium..	7,268	24.1	0.63	29.	
1842	Devaux Marichaie, Belgium......	11,502	17.7	1.34	39.6	
1844	De Basquet La Re Union, Belgium	18,802	25.4	1.18	27.5	
1845	Le Sorine Val Benoit, Belgium....	19,325	26.9	0.51	26.	
1845	Fabry Le Gouffre, Belgium.......	17,800	12.3	2.08	57.	
1852	Lemielle-St. Martin	29,433	11.	1.65	63.4	
	Struve, Risca, S. Wales........ ...	43,866	17.5	2.31	38.	
	Struve, Gwm Avon................	53,920	16.	3.50	42.	
	Nixon Lower Duffryn............	92,700	35.	3.00	39.	

CENTRIFUGAL FANS.

Year.	Furnaces.	Volume.	Coal per H. P. per hour lbs.	Water Guage in inches.	Useful effect, per cent.	Remarks.
1859	Guibal Sacre Madam, Belgium....	58,951	12.3	5.31	56.6	
1869	Guibal Staveley, 30 ft..............	104,229	10.9	2.95	65.24	
1867	Guibal Trimdon, 23 ft............	57,792	10.8	1.60	64.89	
1864	Guibal Ellswick, 23 ft............	60,441	10.4	1.40	67.56	
1870	Guibal Whlkhaven, 36 ft..........	182,000	10.6	5.00	66.41	72 revolutions per [minute.
1870	Guibal Eston Mines, 37 ft.........	212,000	....	3.50	.....	
1867	Guibal Herne Hill, 16 ft...........	51,700	9.3	1.75	75.00	Not accurate, 25% [natural ventilat'n
1860	Guibal Pelton, 30 ft................	102,777	10.6	2.90	66.21	
1868	Waddle Pelton, 30 ft..............	101,384	17.4	2.60	40.15	
	Waddle High Park, 30 ft.....	114,360	.. .	3.56	54.	
1869	Ramwell Framwell Gate, Moor...	53,600	17.5	2.15	40.	
1880	Schiele, Norley Hall...............	140,374	13.2	1.68	53.	
1887	Capel (Waleswood 10)............	123,000	8.6	3.00	82.	

The Guibal fan named in the table just quoted is the invention of the late Theophile Guibal, President of the School of Mines at Mons, Belgium, and part owner of the colliery at La Grand Buisson in the Province of Hainault in that country.

The leading characteristics are structural form, the proportions of the evassé chimney, and principally the use of a movable shutter for the purpose of regulating the width of the outlet; or, as its inventor put it, "adjusting the fan to the temperament of the mine." This term "temperament" is an ancient form of what Mr. Daniel Morgue calls the equivalent of orifice, and was attained by actual experiment rather than by theoretical deduction.

This Guibal proper, doubtless known to a great many of you, is illustrated by drawing on wall.

We have selected Elswick on account of its having given the highest percentage of useful effect of any of the many Guibals tested in the halcyon days of that fan and because the experiments were carried out with great circumstance by Mr. Wm. Cochrane, one of the ablest and most untiring advocates of the Guibal fan. As a director of colliery companies, and as a mining engineer of wide practice, Mr. Cochrane has been instrumental in causing the erection of more Guibal fans than any one person, living or dead. However, it may not be out of place to say that Mr. Cochrane has been converted late last year by the success of the Capell fans at Hutton Henry, and at Backworth, and is now having a Capell fan built for use, at his own colliery; and, while making this little digression, Mr. President, we may as well say that in September, 1894, a 12½ foot double inlet Capell replaced *four* Guibals from 45 feet diameter downward, at La Grand Buisson colliery. That was before M. Guibal's death.

But to continue the description of the Guibal fan. It will be observed that for the greater part of its circumference, it has no spiral chamber, the tips of the blades running two inches clear of the housing or case. If a perpendicular be dropped from the center of fan and a radius be drawn from center to perimeter, at a point where case begins to expand to form the chimney, it will be seen these two lines subtend an angle of 25 degrees. Then again, if we draw a radius along the center line of one of the arms of hub until we come to the perimeter, and select a point in that radius, where the first intersection of arms and braces takes place, the arm carrying the blades of the fan makes an angle of 67½ degrees with the radius we have first drawn.

This description, you will bear in mind, applies generally to the Guibal fan proper, and specially to this Elswick fan, which did the highest percentage of mechanical efficiency of all, tested before or since. We would like you particularly to notice this, because it is the design of Monsieur Guibal and not of any improver *who did not improve.*

We will now call your attention to another drawing; in this case we have selected the type of fan illustrated in Mr. Daniel Morgue's book. It is still a Guibal, in respect of its having an efficient chimney and moveable shutter, also the same character of case, the tips of vanes running within two inches of the case, but the spiral of chimney commences in this fan a few degrees on the outlet side of the perpendicular before referred to, instead of 25 degrees on the other side. But these are not the special points to which your attention is called; it is the form of the blade we would ask you to notice. You observe they are radii, except at the roots where they are curved with the chords towards the direction of rotation. Mr. A. L. Heavenson, in the preface to his translation of Mr. Daniel Morgue's admirable and interesting book, describes a fan he was then building on the same lines for use at Page Bank colliery, Durham, England, but the world has heard very little of the results obtained by it. The same principle was carried out in a more pronounced form in the German fan of Wagner & Rottinger, with even more captivating results in the way of manometrical efficiency than those obtained by Mons. Morgue. But rigid and unequivocal tests made by German engineers demonstrated a mechanical efficiency of only 29 per cent.

It is an acknowledged fact that fans with their blades hooked in the direction of their rotation are capable of giving higher gauges at the same perimeter speeds than other fans whose blades fall away from the direction of rotation. But such excess of manometric efficiency is invariably accompanied by a diminution of mechanical efficiency, and all experiments and practice point to these changing relations as though they were of the nature of a general rule.

These remarks on the Guibal fan have been made, mainly, with a view to call attention to the fact that the fan we call a Guibal is a Guibal in part only, with something else added to it. That it has the wings of the Guibal and the spiral case of the Schielé, and it may, under such favorable conditions as the inlet open to the air, give an output in excess of its body capacity; a thing impossible except as to the very small unmeasurable quantity due to compression within the case, with a Guibal proper, though in practice in mines, so far as we know them, the body output is usually very much under cent per cent. Our fan, properly described, may be called a Schielé-Guibal, or in other words, a partial Guibal with the Schielé spiral case, and partaking of the Schielé character of low, useful effect.

High manometric efficiency, when not associated with high mechanical efficiency, in a fan is a direct proof that such fan is absorbing a large percentage of the power required to drive it, *in friction within itself*, for, if otherwise, the air would, by the law of the flow of fluids, rush in at a velocity more or less nearly approaching that acquired by a body falling from the top of a column of air equal to gauge in weight, *as the inlet conforms in outline to that of vena contracta*, or as the fan performs the functions of that form of inforce.

One of the latest and most flagrant cases which came under our notice was that of a fan at Backworth colliery, Northumberland, where the 45 x 13 foot Guibal fan gave *87,000* cubic feet of air at 2¾ inches water gauge, while the 13½ x 5½ Capell gave 126,000, at under 1½ inches without any alteration in the laying on of the air of the mine or of the airways. This difference is a measure of the friction within the fan itself or what Mr. Morgue calls the orifice of passage.

In testing an existing fan or mine, for volume and water gauge, with a view to ascertain the power required for a larger quantity, we invariably place the water gauge in the drift 6 feet away from the fan entrance and usually on stoppings for some distance in bye and prefer to make the end of gauge proper with flannel. We find that the common fan here, while giving low gauges, does not give the illusory gauge of the Guibal proper before referred to: this is likely owing to the spiral case giving scope to centrifugal force in the moving air instead of compression in the spaces between the blade while running between the point of cut-off and flare of chimney.

In choosing a fan for any particular work it would appear that the first question to ask ourselves is, how much air do we require our fan to produce.

(*a*) Ordinary working quantity.

(*b*) Contingent quantity to meet future requirements in the extension of our mine or some extraordinary demands which might arise if under abnormal conditions.

Then we must ascertain how much air we have now, being careful not to overmeasure the quantity. The water gauge must be taken simultaneously with the air, and with equal care; the precaution in this case being against getting too little gauge. Having measured our quantity and gauge, we use an infallible rule, verified a thousand times by mining men of every country, that the square of the quantity *we have* is, to the gauge *we have*, as is the square of the quantity we require, is to the gauge we require. A simple illustration of this rule may be of service to some practical men present: "We will say we have 27,000 cubic feet of air and 3 water guage and we want 108,000, then $\frac{108{,}000^2 \times .3}{27{,}000^2} = 4.8$ inches.

We should bear carefully in mind *that this result has nothing to do with what kind of a fan we use, it is simply a function of the mine.*

Then having found the water gauge we require to pass the quantity of air we have fixed upon as necessary to meet our case, the next step is to find makers of fans who will guarantee to give us the quantity *at the gauge.* We should be careful to make our guarantee a binding covenant to give the quantity *at the gauge*, the only saving clause admissible being, if the mine will pass the quantity at the gauge. We ought to be careful to see that our engine power is more than sufficient to provide for the quantity we have fixed upon, to guard against such a contingency as compulsory lowering of boiler pressure. We then examine into the commercial aspects of the case.

(*a*) What percentage of mechanical efficiency must we have?

What are the first costs of the several fans which are guaranteed to fulfill our requirements, say per horse-power per hour in the air, or per million foot pounds in the air.

And here we would say that it would be a good thing if mining engineers would set up some standard unit of duty for mine fans, like mechanical engineers have done for the duty of pumps, viz. million foot pounds developed by the consumption of 100 pounds of coal—in Great Britain it is one bushel of Welsh steam coal.

(*b*) The cost of running, including redemption of capital, say per billion foot pounds in air or per horse-power per year.

(*c*) The wearing qualities and behavior of fan in case of fire in return or other part of the mine.

(*d*) Space occupied.

(*e*) Which fan will give the air we require with the least *or without any* alterations in airways.

These and other like considerations which might suggest themselves, would appear to us to be determining factors in the choice of a fan; and "we should be especially careful to guard against being over-persuaded by persons who might represent that their fan will pass the wind we require through the mine, which in the hypothetical case worked out was shown to be 4.8 inch water guage, with two inches or anything less than the guage we have ascertained by computation to be the guage we require." The gentlemen who would so persuade us, are in the same position as the man who would have us believe that he can put us in the way of getting our breath through the stem of a tobacco pipe, without expending any more energy than is necessary to get it through a 3-8 glass tube. And we should not, in the present state of knowledge on the subject of fans, accept the fan of any man who tells us that he can give us 70 per cent. of manometric efficiency, until we are convinced that he has distanced all competitors in the general excellency of the thing he has to offer; but we are more likely to find that the manometric efficiency of his fan measures its mechanical efficiency in an inverse ratio, as we have already seen that high manometric efficiency and low mechanical efficiency—or small output of air—are usually found together.

The late John J. Atkinson, author of "Treatise on Gas Met With in Coal Mining," puts down the average of the best furnaces in the North of England as using not less than 40 lbs. of coal for every horse-power per hour in the air. With our shallow shafts we may safely put down the consumption at 60 lbs. at least for the same duty, and where the water gauge is considerable and the furnace has to be forced, at very much more.

The various experiments made with Guibal fans in England, appear to be based on 7 lbs. of fuel consumption for every horse-power given out by the engine. And for all Guilbals tested about 1869, the same fuel consumption to within a fraction of a pound appears to be obtained.

From personal knowledge the writer is aware that the fans and engines were not tested as a whole installation, and as the engine and boilers differed in construction in nearly every case, this uniformity in results is somewhat bewildering. The whole of the engines driving the fans of the Staveley Company are of one kind, with piston valves and cut-off so as to exhaust near the atmospheric line, and the same may be said of the many fan plants built by that company for other mines. In other words, the coal consumptions given in table are deduced from mechanical efficiencies of the several ventilators on the assumption that each engine consumes 7 lbs. of coal for every indicated horsepower; while this may not give the actual quantity of coal burnt, it gives a fair comparison of the fuel bill of the several ventilators. The actual discrepancies can be so small that they did not seriously affect the results in making comparisons. With a well built engine, such as is used for electrical generation, at a good piston speed and, not later than ¼ cut-off, driving a Capell fan, we may safely count upon a lower coal bill than has yet been obtained in practice without using compound engines.

Thus, in a somewhat desultory way, we have endeavored to present to you food for discussion. The steps in economy proceeded steadily up to the advent of the Guibal and we would repeat here that we cannot too rigidly fix in our minds "that the Guibal of books and of foreign countries is not the fan that we call by that name." The apparent economy of the Guibal stood unchallenged and its position unrivalled—though the Waddell ran it close—until Capell built the Waleswood Fan.

The subsequent substitution of Capell fans for Guibal's at Continental collieries, notably at Grand Horne, Belgium, revealed the fact, that Guibal gauges were fictitious gauges, and that the economies obtained or claimed and accepted for years without question, were based on guages taken on the fan case, whereas two guages, one on the fan case and one on the drift, six feet away from the inlet opening, showed a difference of as much as 40 per cent. in some cases. The discovery arose from finding that as a matter of fact, the substituted Capell fan passed more air than that due to the square root of the water gauge called for; thus it appeared as though the Capell would pull more air with less gauge, in the same mine; but those in charge of the mines were too intelligent to fall into such a delusion. So the cause was sought and found, as stated in reference to Backworth. The gauges from which the new quantity had been calculated were based on gauges higher than the true gauges of the mines.

Very recently an enquiry has been made into the subject on behalf of the German Government, as much surprise had been expressed by the commissioners that the calculated and actual gauges required to pass the stipulated volume by the Capell fans put to work in the Royal mines differ so much. The report will be found in tabulated form below, which have, for convenience, been transposed from metrical into United States measurements.

Report of a comparison of Capell and other types of fans on *same upcast shaft* on German mines laid before German Commissioners:

Name of Mine.	Type of Fan.	Former Results.		Results with Capell.		Calculated Results from Old Fans.	
		Vol. cu. ft.	Guage inches.	Vol. cu. ft.	Guage inches.		
Prosper No. 1.....	Guibal, 40 ft.........	56,496	3.14	95,337	10.63	95,337	15.74
Consolidation....	Guibal, 40 ft..........	70,620	1.968	134,178	4.527	134,178	7.08
New Isolonn.....	Pelzer fan............	68,501	2.48	99,397	4.36	99,397	6.
Erin..............	Union Co's., Schiele.	80,744	2.95	116,523	3.93	116,523	5.19
Victoria..........	Union Co's., Schiele.	42,372	3.64	70,620	5.51	70,620	9.84

[Applause.]

Owing to the absence of the writer of the foregoing paper, no discussion was had of the same; and on motion of Mr. Haseltine, a vote of thanks was tendered Mr. Clifford for his able paper.

The matter of election of officers was taken up. Moved by Mr. Beattie and seconded by Mr. Miller, that the rules be suspended and the ballot of the Institute be cast for the present officers to serve for the ensuing year. Same was done and the following officers declared elected for the coming year:

President.................Prof. F. A. Ray, Columbus.
Vice President................Henry Price, Jackson.
Secretary-Treasurer..Robert M. Haseltine, Columbus.

EXECUTIVE COMMITTEE.

Prof. N. W. Lord, John Kane, Capt. J. L. Morris.

Mr. F. W. Fowler, of Blue Rapids, Kansas, was found to be present, but had prepared no paper upon the subject assigned him, "The Jumbo Auger." In lieu of same he explained the implement as follows:

MR. FOWLER: I have here a very simple device which cuts a three inch hole, making a powder pocket at the rear of a two inch hole, getting all the powder in one small space. We first bore a two inch hole, five feet four inches deep, then insert the Jumbo Auger and drill a three inch hole eight inches back of that, making six feet. In this way the powder is concentrated at the end of the hole and better results are obtained. We have found it so in every case. We have put them in every mine in the Fremont district. This auger (indicating the one in his hand) has been used in boring nearly two thousand holes and has never been in the blacksmith shop. Its use causes an increase of lump coal, for the reason that there is perfect combustion of the powder, and the full force of the shot is secured, giving a pushing, rather than a shattering force. Where you have two feet of powder in a two inch hole and ignite it at the front end, half the powder is not burned and the coal is blown all around the room. That is impossible with the use of this method, and it is very rarely that we hang up a shot. Of course, in experimenting, in cutting down the amount of powder, once in a while we may get too small a quantity and fail to make the coal. In regard to blown out shots, with the shoulders which this auger puts in the hole, it is impossible to blow the shot.

President Ray: Explain how it engages in the end of the hole?

Mr. Fowler: This is simply an eccentric. You force this point (indicating) into the face of the coal and it will not travel anywhere except in the center, and swings around like this (indicating). The bit measures two inches from the center point to the outer edge of this projection (indicating). Consequently, it will go into a two inch hole; and being an inch and a half from here to here (indicating) it cuts a three inch hole.

Mr. Love: If that simple device will do away with making so much smoke, it is indeed very valuable. If you first bore a hole two inches in diameter and by means of this kind of a bit increase it to three, you could not push the cartridge through the first hole to fill up the back space. But his object, I take it, is to put it in there loosely and let it have a chance to expand to the amount of one-half inch on each side in order to consume all the powder in the shot. It is a fact that in tamping it in the hole tight and filling all the space with powder, it does not all burn, more especially where the cartridge used is more than two feet in length. This method, I think, undoubtedly gives a chance for all the powder to burn on account of the large chamber.

MR. FOWLER: The manner in which we load those holes is this: We usually make the cartridge with a newspaper, put it back lightly with a tamping bar, a little wad of paper on top, and then gradually push it until it doubles up and there leave it in the three inch chamber, and put in the needle. The idea is to burst the cartridge in order to get a two foot cartridge in an eight inch pocket.

PRESIDENT RAY: Have you any drills at work in Ohio?

MR. FOWLER: Mr. Poston at Nelsonville is using them.

MR. DOE: I would like to ask Mr. Fowler what effect this manner of shooting would have in soft or tender coal?

MR. FOWLER: In Illinois, it works very well; also in Kansas and Missouri, where the coal is very soft. In Texas and Rock Springs the coal is much softer than this coal at Monongahela. We have never tried it anywhere yet where it did not work successfully.

MR. DOE: The coal I am speaking of is a very easy shooting coal and very tender. I think they use about ten inches of powder. My idea would be that your manner of shooting would work very well.

MR. FOWLER: I stopped at Nelsonville lately, being too ill to proceed, and the next day I inquired and found that Mr. Poston was a mine operator who had an office in town. I saw him and told him what I could do, and he said they mined by electricity and he did not think I could help them any. But I took three drills out to the mine and left them there four days. On the fourth day he came to me and told me they couldn't get along without them; they increased his lump coal very much. That was a case where they were using very little powder.

MR. RUTLEDGE: How does the machine work in electrically undermined coal?

MR. FOWLER: I had a thorough demonstration of that at Mononga, No. 2. The superintendent was disgusted with the results they were getting in shooting their coal, which was cut with a chain undercutter. They were obliged to dig down with a pick more than half the coal after shooting. With this tool they got a direct push ahead and found no difficulty in pushing it out slick and clean with every shot. It shows that it gives as much power pushing out as down.

MR. DOE: I move a vote of thanks to Mr. Fowler for his explanation of the Jumbo Auger.

Motion seconded; carried.

Thereupon, on motion, meeting adjourned until 1:30 p. m. same day.

AFTERNOON SESSION — JANUARY 21, 1:30.

The President opened the meeting and announced the first paper to be on the subject of "Adaptation of Multi-phase Alternating Current System of Power Transmission to Mining Apparatus," by Mr. C. R. Thomas. Mr. Thomas prefaced the reading of his paper as follows:

MR. THOMAS: Mr. President and members of the Institute: It would be a poor tribute to the intelligence of this body of men if in presenting this paper I was to deal in ancient history; or, in other words, attempt to describe all which has been done in years past on mining machinery. I take it, you would much prefer to know what is being done at the present time, or what can be done.